DRAFT

WORK PLAN:
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
AT THE NORTH RIDGE ESTATES SITE,
KLAMATH FALLS, OREGON

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June 7, 2005

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Submitted By:	**Reviewed and Approved By:**
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 EXECUTIVE SUMMARY

This is a work plan to conduct a remedial investigation/feasibility study (RI/FS) at the North Ridge Estates Site in Klamath Falls, Oregon. It is designed to address concerns related to the presence of asbestos-containing material (ACM) debris that has been observed in soils at the site, concerns related to the possible presence of other chemicals of potential concern (COPC's) in environmental media at the site (that are alleged based on knowledge of historical activities), and the potential for the asbestos (or any other COPC's) contained in site media to be released to the environment in a manner leading to exposure and risk.

This work plan has been prepared pursuant to Unilateral Administrative Order (UAO) for Remedial Investigation/Feasibility Study (Docket No. CERCLA-10-2005-0090) issued by the U.S. Environmental Protection Agency (EPA), Region 10, effective March 15, 2005, for North Ridge Estates (the "Site"). The site was formerly the location of the Klamath Falls Marine Recuperational Barracks after World War II and subsequently the Oregon Technical Institute. The RI/FS Work Plan was completed by PBS Engineering and Environmental (PBS) and Aeolus, Inc. (Aeolus) on behalf of the Respondents, Melvin Stewart, Mary Lou Stewart, M. L. Stewart, Inc., and Kenneth L. Tuttle as Trustee of the Kenneth L. Tuttle MD, PC Employees Profit Sharing and Pension Fund for Kenneth L. Tuttle, and Maurice E. Bercot.

Given the above, the overall goal for the proposed RI/FS for the Site is to provide the data and evaluations required to support the development and comparison of remedial options suitable for achieving the objectives stated in the first paragraph (above) and to provide sufficient information to select and design for implementation the most cost-effective combination among the alternate options defined.

Importantly, decisions at the site are to be risk based. Thus, the specific objectives of the proposed RI/FS are to:

- determine the risks posed to residents at the Site using the information collected to date (a screening risk assessment) and to identify any data gaps that will need to be filled to complete a comprehensive (baseline) assessment of site-related risks;

- conduct any early actions that may be required to mitigate any immediate threats to human health that are identified as part of the screening risk assessment;

- conduct a remedial investigation to provide data of known quality that are sufficient to:

  - fill data gaps and complete a baseline assessment of site-related risks;
  - identify remedial options to address conditions posing unacceptable risks identified at the site;
  - support a feasibility study for the site; and

- conduct a feasibility study in which remedial options are fully developed, evaluated, and compared to facilitate selection of a final remedy that achieves the overall risk-management objectives for the site (which are stated in the first paragraph above).

North Ridge Estates is located on the site of the former Klamath Falls Marine Recuperational Barracks facility, built in 1944 by the United States Department of Defense to receive and care for marines who had contracted tropical diseases while fighting in the Pacific theater in World War II. More than 80 buildings were originally constructed to house, feed, and provide routine services and medical care to the troops. After 1947, the complex was transferred to the State of Oregon, which operated it as the Oregon Technical Institute (OTI).

As preventative maintenance was not generally performed by OTI, site buildings rapidly deteriorated. The OTI relocated to a site in Klamath Falls and the former barracks property subsequently passed into private ownership in 1966. Most of the buildings were reportedly salvaged of materials of value (wire, pipe, lumber) and demolished in the mid- to late-1970s. In 1977, the site was purchased by the MBK partners, who sub-divided the site and in 1993 began construction of luxury homes on the individual parcels.

In the late 1970s, the DEQ and the EPA became aware of large quantities of ACM scattered throughout the site as a result of demolition activities. In 1979, EPA issued an order requiring MBK to fully contain all asbestos at the site, primarily through burial, and identify properties known to contain asbestos materials.

An EPA Removal Action conducted in 2003 included the hand removal of nearly 84 tons of surface ACM debris across the Site, identification of burial piles, location of buried insulated steam lines, sampling and analysis as initial characterization of risk at the site. Both chrysotile (a serpentine asbestos) and amphibole asbestos were identified. Sampling was also conducted across the site to provide an initial characterization of asbestos concentrations in surface soils, indoor and outdoor air, and household dust. An activity-based sampling study was also conducted, during which air samples were collected while a series of activities were conducted under controlled conditions on contaminated soil. Results of these studies are provided in a series of reports.

The sources of asbestos at the site and the pathways by which such asbestos might be released and transported to locations where exposure may occur (which leads to risk) are summarized in an initial Conceptual Site Model (CSM). A preliminary assessment of site risks identified in the CSM, which are based on the data collected at the site to date suggests that:

- each of two general types of asbestos have been identified at the site: chrysotile (a serpentine asbestos) and amphibole asbestos;

- for at least some locations at the site, bounding estimates of asbestos-related risks associated with near-term exposures relating to dust generation from certain residential activities exceed both the range of risks potentially considered acceptable by EPA and the action levels set by the DEQ; and

- among asbestos types, elevated bounding estimates are driven by the presence of amphibole asbestos.

Because certain questions need to be answered before an efficient investigation of the entire site can be designed, the overall approach proposed for this RI/FS is to conduct a phased RI while developing options for remediation as part of the FS. The initial phase of the proposed RI would be focused on answering general questions about the site that are required to complete overall scoping and planning. These are:

- whether the approach used at this site for assessing asbestos-related risks is adequately reliable;

- whether alternate sampling and analysis methods for the determination of asbestos in soil and bulk materials can be shown sufficiently precise, accurate, and cost-effective to supplement/replace the primary approach being employed at the site;

- whether it can be confirmed that the extent of amphibole contamination at the site is sufficient to drive risks (as has currently been supposed, see Section 4.3);

- to better identify and refine a preliminary list of response options: whether asbestos contamination over most of the site extends to depths greater than a couple of feet;

- whether asbestos contamination exists at locations other than those associated with the footprints of former buildings; and

- whether other COPC's are present at the site that will need to be addressed during remediation.

Once the initial phase of the proposed RI is completed and a preliminary list of remedial options are identified as part of the proposed FS, the objectives for the final phase of the RI will be defined. In the final phase of the RI, the site will be characterized with sufficient precision to support development, evaluation, and selection among remedial options for the site. The proposed FS will then be completed in a manner suitable for supporting a record of decision.

2 INTRODUCTION

This is a work plan to conduct a remedial investigation/feasibility study (RI/FS) at the North Ridge Estates Site in Klamath Falls, Oregon. It is designed to address concerns related to the presence of asbestos-containing material (ACM) debris that has been observed in soils at the site, concerns related to the possible presence of other chemicals of potential concern (COPC's) in environmental media at the site (that are alleged based on knowledge of historical activities), and the potential for the asbestos (or any other COPC's) contained in site media to be released to the environment in a manner leading to exposure and risk.

This work plan has been prepared pursuant to Unilateral Administrative Order (UAO) for Remedial Investigation/Feasibility Study (Docket No. CERCLA-10-2005-0090) issued by the U.S. Environmental Protection Agency (EPA), Region 10, effective March 15, 2005, for North Ridge Estates (the "Site"). The site was formerly the location of the Klamath Falls Marine Recuperational Barracks after World War II and subsequently the Oregon Technical Institute. The RI/FS Work Plan was completed by PBS Engineering and Environmental (PBS) and Aeolus, Inc. (Aeolus) on behalf of the Respondents, Melvin Stewart, Mary Lou Stewart, M. L. Stewart, Inc., and Kenneth L. Tuttle as Trustee of the Kenneth L. Tuttle MD, PC Employees Profit Sharing and Pension Fund for Kenneth L. Tuttle, and Maurice E. Bercot.

2.1 PURPOSE AND SCOPE OF WORK

As indicated in the UAO (and as supplemented during recent discussions with the agency), the primary objectives of the RI/FS process (i.e. the risk-management objectives) to be implemented at the Site are to protect public health by:

- eliminating unacceptable cancer and non-cancer impacts posed by the presence of asbestos in soils, by all relevant pathways in which asbestos may be released from such soils and lead to exposure via inhalation, ingestion, or dermal contact[1] (including disturbance of contaminated soil by residential or construction activities); and

- eliminating unacceptable cancer and non-cancer impacts posed by the presence of any other Contaminants of Potential Concern (COPC's) that may be identified at the site by addressing any sources at the site in which the presence of such COPC's are confirmed.

Given the above, the overall goal for the proposed RI/FS for the Site is to provide data and analysis that are sufficient to define and design options for achieving the objectives stated above and to provide sufficient information to select for implementation the most cost-effective combination among the alternate options defined. Thus, the specific objectives of the proposed RI/FS are to:

- determine the risks posed to residents at the Site using the information collected to date (a screening risk assessment) and to identify any data gaps that will need to be filled to complete a comprehensive (baseline) assessment of site-related risks;

- conduct any early actions that may be required to mitigate any immediate threats to human health that are identified as part of the screening risk assessment;

- conduct a remedial investigation to provide data of known quality that are sufficient to:

  - fill data gaps and complete a baseline assessment of site-related risks;

  - identify remedial options to address conditions posing unacceptable risks identified at the site;

  - support a feasibility study for the site; and

- conduct a feasibility study in which remedial options are fully developed, evaluated, and compared to facilitate selection of a final

[1] Although listed above for completeness, there is no known evidence that asbestos can pose a hazard to human health through dermal contact. Therefore, asbestos risks attributable to the dermal route of exposure will not be considered further in this document. Also, evidence that asbestos is a hazard when ingested is limited (USEPA, 1986). In fact, even the drinking water standard for asbestos is extrapolated from what is essentially a negative study (Mullin and Patel, 1991). Therefore, given the lack of strong evidence of a hazard coupled with the lack of an appropriate dose-response factor for this route of exposure, pathways involving ingestion of asbestos will not be addressed further in this RI/FS either.

remedy that achieves the overall risk-management objectives for the site (which are stated above).

Given the costs for sampling and analysis to determine the concentrations of asbestos in source materials (in a manner suitable for supporting risk assessment), limited study is also proposed to evaluate potentially applicable and cost-effective alternatives that might be used to supplement the current approach for asbestos sampling and analysis. This will be done to better facilitate completion of an RI that satisfies the second to last of the objectives listed above.

Note that, while the goals and objectives listed above capture the intent of the objectives defined in the UAO, they have been reorganized in the above discussion to facilitate application of the DQO process (see Section 5.2).

2.2 ORGANIZATION OF THIS DOCUMENT

This Work Plan provides a summary of known historical activities at the Site including construction and demolition of buildings, regulatory activities and previous investigative work. Important to understanding the distribution and migration of contaminants, the physical character of the Site is presented (Section 3).

Section 4 presents preliminary conclusions formed by work to-date at the Site with respect to existing Site contaminants and distribution, including a Conceptual Site Model. Preliminary response objectives and options are presented.

A description of the proposed technical approach to the RI, including a discussion of how the Data Quality Objectives (DQO) Process will be applied to define the types and quality of data required to support key site decisions, is presented in Section 5. Based on the considerations addressed in this section, it is proposed that the RI for the site be divided into two phases: an initial phase designed to address considerations that need to be resolved to support planning for comprehensive characterization of the site and a final phase in which the site will be characterized adequately to support the main objectives of the RI.

Finally, the Work Plan describes each of the required tasks of the proposed RI/FS (Section 6) and presents estimated costs (Section 7), a schedule for completion (Section 8), and the Project Management plan (Section 9).

3 SITE BACKGROUND AND PHYSICAL SETTING

A description of the site, its location, physical characteristics and history are provided in this section.

3.1 SITE LOCATION

North Ridge Estates is located approximately three miles north of the City of Klamath Falls at an elevation of 4,500 feet (Figure 1) in portions of Section 15, Township 38 South, Range 9 East (Willamette Meridian). The 422-acre subdivision is developed along both sides of Old Fort Road and North Ridge Drive (Figure 2).

3.2 SITE DESCRIPTION

Site Name: North Ridge Estates, Klamath Falls, Klamath County, Oregon
Formerly, a portion of the Klamath Falls Marine Recuperational Barracks

Oregon DEQ Location ID: 40764
Oregon DEQ ECSI Number: 2335
U.S. Army Corps of Engineers Property Number: F10OR057000
Formerly Used Defense Sites (FUDS) Site Number: 570

Site Center Coordinates: Latitude 42° 15’58” North
Longitude 121° 44’46” West

The developed area of the subdivision (illustrated on Figure 2 by lot owner names) west of Old Fort Road currently has 21 homes, 2 privately-owned vacant parcels; 7 vacant parcels, 1 warehouse parcel and 1 rental home owned by MBK Partnership, and the Memorial Park. The Oregon Department of Health Services (ODHS) reports that there were 77 residents, including 35 children, in the developed area of the site (ODHS, 2003).

This area is the primary focus of the UAO. The Site also includes adjoining or nearby areas that have been affected by wastes generated from the developed area and may be further expanded to address additional considerations, subject to the findings of the proposed RI.

East of Old Fort Road are several homes, a five-unit apartment building and the Thicket Court residential homes. Land to the west, north, and east of the subdivision is zoned for forestry, grazing, and agriculture. Other more rural residences are present to the south and north of the site, along Old Fort Road. According to the 2000 U.S. Census, there are 98 residents, including 14 children age 6 and under, within one half mile of the North Ridge Estates property (ODHS, 2003).

3.3 SITE HISTORY[2]

North Ridge Estates is located on the site of the former Klamath Falls Marine Recuperational Barracks facility, built in 1944 by the United States Department of Defense to receive and care for marines who had contracted tropical diseases while fighting in the Pacific theater in World War II. More than 80 buildings were originally constructed to house, feed, and provide routine services and medical care to the troops.

Most of the military barracks buildings were west of Old Fort Road. A sewage treatment facility and horse barns were built one-quarter mile to the north. A medical laboratory, dispensary, medical staff housing, the brig, and a rifle range were built on the hillsides east of Old Fort Road. Operational buildings near the north end of the site, and west of Old Fort Road, included the central power plant, warehouse, maintenance shop, bakery, and laundry buildings. A gym and indoor swimming pool buildings were located at the south end of the site, west of Old Fort Road. Figure 3 shows the site layout as mapped by the U.S. Marine Corps Reserves in 1945.

In 1946, the Marine Recuperational Barracks closed and the property was transferred to the State of Oregon for use by the Oregon Technical Institute (OTI - now Oregon Institute of Technology) until the early 1960s. The Oregon Institute of Technology relocated to a site in Klamath Falls and the former barracks property subsequently passed into private ownership in 1966.

From 1966 through the mid-1970s, property owners reportedly stripped the vacant buildings of salvageable materials such as copper and wood. Asbestos insulation reportedly was stripped from piping and boilers, metal was sold, and the insulation remained at the site. The idle site was further subject to vandalism.

The North Ridge Estates property was purchased in December 1977 by MBK Partnership of Klamath Falls. Following their purchase, additional buildings remaining on the site were demolished.

MBK subdivided the site into residential lots. Klamath County approved subdivision plans, and construction of homes in the subdivision began in 1993. Twenty-two of the lots in the project area have been developed as single-family houses, and are now occupied for residential use. Other undeveloped lots remain in private ownership or are owned by MBK.

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[2] Portions of this Section are based upon the author's review of readily available information, some of which may conflict. Accordingly, this section is not intended to provide a definitive or exhaustive site history, nor is it in any way intended to constitute factual admissions on behalf of the Respondents.

3.3.1 History of Ownership

The first documented ownership of the Site was by the United States for use by the Marine Recuperational Barracks from 1944 through 1946.

The State of Oregon obtained ownership of the Site in 1947 for use by the Oregon Technical Institute, and returned the property to the United States in 1964.

In 1966, a group of individuals known as the Engelberg group acquired ownership from the United States.

The Engelberg group conveyed the site in 1977 to Melvin L. Stewart, Maurice E. Bercot, and Kenneth L. Tuttle, MD, PC, Employees Profit Sharing and Pension Fund for Kenneth L. Tuttle.

This group transferred ownership to MBK Partnership in 1977. As of 1993, MBK Partnership consists of Melvin L. Stewart and Kenneth L. Tuttle, MD, PC, Employee’s Pension and Profit Sharing Plan and Trust Agreement.

3.3.2 History of Construction and Demolition Activities

This section is intended to present a summary of historic activities. Site history will be presented in more detail in the Site Background Data Report, Subtask 1.6 (see Section 6.2.6).

The marine barracks facility constructed in 1942 consisted of approximately 84 buildings, the majority being standard 148’ by 40’ two-story temporary barracks; a large central mess hall, officers quarters, theater, laundry, swimming pool, gymnasium, garages, dry cleaning Quonset, storage buildings, a brig, medical hospital and rifle range. The facility had its own fire station, sewage treatment plant, water-heat-electrical distribution systems and storm drains.

The original construction was designed for temporary use by the military. Buildings were one and two-story structures with wood framing and floors, interior walls and ceilings of 3/8” gypsum board over wood studding, and exterior walls and roofs of 3/16” cement asbestos board over ½” gypsum board, set on concrete foundations (OTI file documents). The *Report and Survey of OTI* (Stevens and Thompson, 1958) concludes that the military facility was not designed or built for long-term usage, and that building materials, electrical and plumbing facilities were inefficient, often not meeting local building codes. Building wall, floor and ceiling insulations were thin “organic fiber type” and noted to be an “inflammable” material (i.e. flammable) that “constitutes a real fire hazard in every one of the buildings where it is used.”

As preventative maintenance was not generally performed by OTI, which began operation at the site in 1947, site buildings rapidly deteriorated. Roofs frequently failed due to snow loading. The covered swimming pool was not used by OTI due to leaks and cost of operation. While the gymnasium and bowling alley were used by OTI and many other buildings were converted for use by the school, a substantial number of buildings remained unused and were left to deteriorate.

Water supply came from the City of Klamath Falls over a 2.6-mile line of 10" steel pipe, boosted at a pump station located offsite to the south. Six aboveground wood stave water storage tanks were located on the hillside southeast of Old Fort Road, and were replaced by OTI with a single steel tank in about 1958.

The sanitary sewage system consisted of 6- to 12-inch diameter vitrified clay sewer pipe throughout the site (including Thicket Court, formerly Klamath Circle), that connected to the treatment plant located northeast of the site. The plant included a clarifier (40' diameter by 7' deep), two biofilters each 44' diameter and 3' deep, chlorine contact tank (7' wide by 16' long and 6' deep), sludge digester (32' diameter and 20' deep) and two open sludge drying beds, each 30' by 100'.

A solid waste, and potentially medical waste, landfill reportedly operated in the northwest corner of the Site. This may also have been a disposal area during later demolition activities.

Electrical power was provided via overhead lines and 17 poles mounted with one or more transformers. Ground-level transformers were located at the COPCO substation at the southeast corner of Old Fort Road and Scott Valley Drive; at substation #1 at Nickerson Hall, at substation #3 at the cafeteria and in a belowground vault at the south side of Cornett Hall.

Heat was provided to the buildings from a central power plant through a closed-loop system of buried asbestos-insulated steam pipes. A small insulated condensate tank was reportedly located in many of the barracks buildings. Interior hot water lines were reportedly not insulated. The marine facility utilized coal for fuel; coal bunkers and an ash collector were located outside of the west side of the power plant. OTI replaced the five boilers with two oil-fired boilers in 1952 and 1957; the oil tank appears to have been inside of the power plant building. As part of the facility survey for OTI in 1958, the steam lines were uncovered and sections were removed, intact, for inspection from 5 locations.

OTI converted use of the facility to classroom, shops and garages, and many of the existing dormitories were occupied by students. OTI offered programs in various industrial arts, including diesel mechanics, electronics, automotive work, medical technology, machine shop, welding and carpentry. OTI ceased operation at the site in 1964.

Historical aerial photographs from 1970 indicate that most of the former marine facility buildings remained intact. Building demolition is evident in the northwest portion of the site, west of North Ridge Drive.

Most of the buildings were reportedly salvaged of materials of value (wire, pipe, lumber) and demolished in the mid- to late-1970s. Reports suggest that insulated pipe was wetted, wrapped in plastic and disposed in onsite pits. The Firehouse was also apparently a storage area for pipe insulation. Non-salvageable materials and debris were either burned or pushed into piles.

The swimming pool structure, built into the hillside to the west, apparently collapsed due to deterioration. The few remaining buildings, including the auditorium and swimming pool, were demolished in the 1980s. Dirt was backfilled into the swimming pool structure from uphill to prevent a safety hazard. Military buildings east of Old Fort Road were demolished; several of the former barracks buildings currently remain in residential use in the Thicket Court area.

3.3.3 History of Actual and Potential Site Releases

- **1970s:** In the late 1970s, the Oregon Department of Environmental Quality (DEQ) responded to a complaint of openly accumulated asbestos debris at the property and observed a bulldozer driving over four to six acres of demolition debris described as a great amount of “white, fluffy” insulation material being blown by strong winds.

- **1993:** The U.S. Army Corps of Engineers (COE) visited the site in 1993 (Gardenhire, 1993) and reported that demolition debris had been buried in a swimming pool, sewage lagoon, and other locations at the site.

- **2001:** In June 2001, DEQ received a complaint of two large piles (180 linear feet) of asbestos-insulated pipe on the surface of a lot being developed in North Ridge Estates. The DEQ inspector observed “white to pale brown-colored platy looking” fragments on the lot and on other lots throughout the subdivision

3.3.4 History of Regulatory Activities and Previous Investigations

In the late 1970s, the DEQ and the EPA became aware of large quantities of ACM scattered throughout the site as a result of demolition activities. In 1979, EPA issued an order requiring MBK to fully contain all asbestos at the site, primarily through burial, and identify properties known to contain asbestos materials. The Order required that coverage and maintenance of the disposal site conform to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

Since the local landfill would not accept asbestos materials, and due to concern about health risks to workers in removing such a large quantity of material, DEQ agreed to allow MBK to dispose of the ACM (primarily steam line insulation) onsite. MBK submitted plans to the EPA to remove asbestos from buildings by wetting and bagging the materials, and placing the bags in basement areas to be agreed to by DEQ. After disposal in the basements, there would be a 2-foot cover of fill over the site (Bercot, 1979). One such basement area has been reported as under the west wing of Nickerson Hall.

The DEQ contacted ODHS Superfund Health Investigation and Education program in May 2002 for assistance in assessing the health risks of exposure to fragments of ACM. ODHS reported that there were no indications that the 1979 EPA Compliance Order NESHAP requirements for proper disposal were met, nor that locations of ACM disposal sites were recorded on property deeds or similar documents, as was required by the 1979 EPA Compliance Order.

An asbestos survey was conducted by Malot Environmental of Central Point, Oregon, for MBK in April 2002. On 28 lots, 1.5 to 5.5 acres in size, ACM was reported on over 50 acres of the 81 acres surveyed. ACM was also reported on 3.5 acres on two of the three larger lots that comprise 223 acres of the property. Lots 1 and 2 of Tract 1267 and most of the acreage of the three larger lots were not surveyed, as they were determined by the asbestos abatement contractor to be outside of the area where military buildings had been demolished. The area east of Old Fort Road was not included in the area surveyed.

Malot Environmental removed over 50 tons of asbestos-containing material from the ground surface during 2002 and disposed of the materials offsite under the terms of a Mutual Agreement and Compliance Order signed with DEQ in June 2002. MBK also submitted maps to DEQ showing known and presumed locations of burial sites and underground piping, paid a civil penalty, and sent notifications to property owners.

Staff from ODHS, the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) regional office, and DEQ visited the site accompanied by a representative of MBK in October 2002. Inspection staff walked through subdivision areas where asbestos had been surveyed, including the Memorial Park, vacant lots and the warehouse, and drove through adjacent neighborhoods. ACM fragments were noted throughout the subdivision areas visited. Visual inspections by ODHS staff indicated that approximately one-fourth to one-half of each occupied home site was covered with lawn and landscaping cover, while other large remaining areas had exposed dirt, rock and sparse vegetation.

In January 2003, DEQ staff identified areas on three additional lots that may be disposal sites. One was located on a vacant lot on North Ridge Drive, a second on a residential lot on Old Fort Road, and a third at the former location of the family dispensary for the Marine Recuperational Barracks east of Old Fort Road.

EPA Removal Action. In June 2003, work commenced on the EPA Administrative Order on Consent for Removal Action and Streamlined Risk Assessment ("Removal Action"). PBS Engineering and Environmental (PBS) and Aeolus, Inc. provided technical assistance to MBK Partnership under EPA oversight. The Removal Action included the hand removal of nearly 84 tons of surface ACM debris across the Site, and removal using heavy equipment of "hot spots", that is, areas of highly concentrated ACM. Suspected areas of ACM burial or deposition, termed "burial piles", were also investigated and 5.6 tons of ACM debris were disposed offsite. A number of the burial piles were later stabilized using fencing, heavy plastic cover and/or placement of rock on slopes to prevent erosion and surfacing of ACM.

Also as a part of the Removal Action, buried steam lines were mapped and investigated using geophysical survey techniques and 10 test pits to confirm the geophysical findings (PBS, 2004a). Detected steam lines were compared to historic utility maps to determine locations where steam lines may have been removed.

Soil sampling was conducted across the site to provide an initial characterization of asbestos concentrations in surface soils, as well as in locations where highly concentrated ACM had been observed (Berman, 2004). Samples of indoor and outdoor air were collected and analyzed to evaluate ambient conditions at each of the homes occupied at that time (Berman, 2003). Samples of indoor dust were also collected and analyzed (Berman, 2005b). The EPA also performed an activity-based sampling study, during which air samples were collected while a series of activities were conducted under controlled conditions on contaminated soil (Berman, 2005a). Soil samples were also collected to determine the concentrations of asbestos in the disturbed soils. The activities simulated in the EPA study included rototilling, weed trimming and child's play (loading and dumping of a bucket of soil).

The EPA identified an area of lead-contaminated soil on Tax Lot 15D 3100 owned by MBK ("MBK-C" in Figure 2). Elevated lead levels in the shallow soil ranged from 600 to several thousand milligrams per Kilogram (mg/Kg) lead. In October 2004, PBS supervised the excavation of an area of approximately 420 square feet to a depth of 1 to 1.5 feet. Confirmation soil samples contained lead at levels approved by the EPA as falling within the target cleanup limit of 400 mg/Kg (US EPA Region 9 Preliminary Remediation Goals, Residential Soil). The excavation was backfilled with clean soil. A total of 26.5 tons of soil was disposed at the Klamath County Landfill (PBS, 2004b).

3.4 PHYSICAL SETTING

The physical characteristics of the site are described in this section.

3.4.1 Topography and Surface Hydrogeology

The site is located in the low rolling hills of the Klamath Basin, a broad, flat valley that forms the northern reach of the Basin and Range physiographic province extending to the southeast across Nevada. The Basin is bordered on the west by the Cascades Range and on the north by the High Lava Plains Province. The Klamath Lake Basin is the western-most “basin” in the province; moving eastward, one encounters a sequence of “rims” and “basins”. Most of the province is over 4,000 feet in elevation.

The North Ridge Estates was constructed in a higher-elevation valley, approximately 4,800 feet in elevation, that lies in a low mountainous area northeast of the city of Klamath Falls and bounding the east side of Upper Klamath Lake. Topographic features include Plum Hills (ridgeline west of the site) and Hogback Mountain (ridgeline east of the site). The site vicinity may have been graded to allow construction of the marine barracks; topography rises upward to the west and east, and the site is centered within an erosional valley that falls off to the north and to the south. Old Fort Road follows this valley.

There are no perennial streams or other surface water bodies in the vicinity of the site. It is likely that surface water follows the topographic drops to the north and to the south, during periods of high precipitation and spring snowmelt. Large lakes filled the basins in the province, that today are diminished due to the more arid conditions that prevail.

3.4.2 Geology and Soils

Soil consists of very gravelly loam formed from weathered tuff, basalt, andesite, and volcanic ash (NRCS, 1985). Tuffaceous bedrock typically is present at depths of approximately 25 to 40 inches below ground surface. Soil is well drained with slow permeability.

The NRCS Soil Survey (NRCS, 1985) rates the soils at the North Ridge Estates area as "moderate potential for frost action". The Oregon State University (OSU) Agricultural Research Klamath Experiment Station reports that maximum soil freezing depths in agricultural areas of the Klamath Basin are 8 to10 inches (personal communication from Dr. Ken Rykbost, Experiment Station Superintendent). Some winters have no freezing of soil. Snow depths typically range from 3 to 5 inches on ground following a snowfall, and melt off within several days. Observations of soil temperatures are representative of the main part of the Klamath Basin, ranging from about 4,100 to 4,300 feet elevation.

Mean minimum soil temperatures at 4-inch depth at the Klamath Experiment Station (3 miles south of Klamath Falls; elevation 4,092 feet) from 1984 to 1998 ranged from 66° F in July to 33° F in January. Soil temperatures at the 4,820-foot elevation of North Ridge Estates could be expected to be approximately 5° F cooler (4 to 6-inch depth). Soil temperatures at 4-inch depth recorded at the Klamath Experiment Station in 2002 were below 32° F only from mid-January to mid-February.

The region is characterized by recent volcanism. Often volcanic landforms are clearly preserved (e.g. Crater Lake and Mount Shasta). These features are accompanied by broad inter-range areas of nearly flat basalt-covered plains. This Basin-and-Range geologic province is a series of long and narrow, north-south trending fault-block mountains alternating with broad basins formed as a result of stretching or extension of the crust and movement of large tectonic blocks. Faults and fissures were accompanied by basaltic volcanic activity, both as lava flows and ash.

The site lies within one such uplifted feature having a mantle of weathered ash and tuff overlying basalt rock. The north-to-northwesterly trend of ridgelines west and east of the site are an expression of the regional geologic structures. Nearby well logs (see next section) show underlying strata that includes alternating layers of clay and sandstone to depths of 300 to 500 feet below ground surface (bgs). One well notes lava rock at 514 feet bgs, the other well continues in clay and sandstone to the final depth of 843 feet bgs. These fine-grained deposits are likely to be thick accumulations of weathered volcanic ash.

3.4.3 Hydrogeology

Wells completed during the last ten years at differing land surface elevations within approximately one mile of the North Ridge Estates site had static water levels ranging from 182 to 390 feet bgs. Records of the Oregon Water Resources Department (OWRD, 2005) show no groundwater wells in Section 15. Domestic water wells addressed at 2050 and 3555 Old Fort Road in Section 22 encountered the first water-saturated zone at 659 and 518 feet bgs, respectively. Static water level at completion was 378 to 390 feet bgs. These aquifers exist within fractured volcanic bedrock (e.g. basalt) or in sandy zones within the fine-grained sediments.

3.4.4 Meteorology

Records of monthly temperatures at Klamath Falls from 1928 to 1998 showed a maximum average temperature of 85 degrees in July and a minimum average of 21 degrees in January (Cooperider and Garrett, 1998). It would be expected that temperatures at North Ridge Estates are 5 degrees or so cooler due to the higher elevation.

Precipitation records over the same time period show a mean annual precipitation of 13.6 inches, ranging from a low of 2 inches in July to a high of 16 inches in December; much of the winter precipitation occurs as snowfall.

A meterological station was operated at the Site by the EPA during the course of the Removal Action in summer 2003. The station was located in the vicinity of the Memorial Park at the northeast corner of the Site. Over three days in mid-August 2003, the wind speed ranged from non-detectable to 6.6 kilometers per hour, and was generally highest in mid-afternoon. Wind direction was generally to the southwest, shifting to the northwest in mid- to late afternoon. Air temperature during that time period ranged from 10.2 to 31.4 degrees Centigrade; barometric pressure from 856 to 858.

3.4.5 Ecological Habitats

Site vegetation is sparse and consists of ponderosa pine-western juniper woodland, sagebrush, shrubs, and grasses. Most of the at-risk wildlife species in the Klamath basin – both terrestrial and aquatic – are associated with wetland and riparian habitats.

The “montane-transmontane” vegetation characteristic of the North Ridge Estates area is not among those habitats considered priority ecological systems for restoration projects by the US Fish and Wildlife Service.(Cooperider and Garrett, 1998). The site vicinity may be important to migratory routes of the numerous bird species that populate the Klamath Basin including waterfowl and bald eagles. Because surface water flows are intermittent, there is no known habitat for fish species in the vicinity.

In the early 1900’s, Klamath County paid bounty money for targeted predatory animals, intended to control the threat to livestock. Such targeted animals included coyote, cougar, mountain lion, panther, wildcat, bobcat, lynx, and wolf.

Deer, elk and pronghorn have been reported to inhabit the site vicinity, as well as occasional sitings of cougar. Burrowing animal activity is apparent around the Site, indicating an active population of ground squirrels, gophers, etc.

3.4.6 Cultural Features

Hudson Bay Company trappers entered the homeland of the Klamath, Modoc and Yahooskin Tribes in 1825. In 1848, gold was discovered in northern California and southern Oregon, and with little regard for the native population, settlers and homesteaders began carving up and taking ownership of Klamath County’s 6,000 square miles. Klamath County was established on October 17, 1882, created from the western part of Lake County and named after a tribe of Indians who white travelers called the Klamath, also spelled Clammite.

The Klamath Indian Reservation was established in 1864 by treaty and covered about fifty square miles of land east and northeast of Klamath Falls. The federal government's policy of termination and assimilation resulted in the tribe being abolished in 1961. However, in 1975 a fully functioning tribal government was reestablished, and the Klamath Tribe was recognized by the federal government in 1986. The 1990 census showed the tribe to consist of 2,370 members.

As a result of this history, there is a potential for historic cultural features to be present in the mountain valley occupied by the North Ridge Estates Site. This potential will be further explored in development of the Site Background Data Report, Subtask 1.6 (see Section 6).

4 INITIAL EVALUATION

What is known about the locations of hazardous materials (i.e. asbestos) at the site and a conceptual site model are presented in this section. Preliminary lists of response objectives and an attendant set of remedial options are also presented.

4.1 NATURE AND DISTRIBUTION OF WASTES

Based on information currently available for the North Ridge Estates Site, hazardous materials were first introduced to the site during the construction, operation, and demolition of a complex of buildings originally constructed by the U.S. Government to house and support Marines with tropical diseases returning from the Pacific Theater in World War II. The specific hazardous materials identified and current knowledge concerning the nature and extent of their presence are summarized below.

4.1.1 Chemicals of Potential Concern (COPC's)

A chemical of potential concern (COPC) is a substance that is known or suspected to cause adverse health or environmental effects when humans or other sensitive species are exposed.

Specifically, it is asbestos introduced to the environment (both as ACM debris and as free asbestos structures) from the original asbestos-containing construction materials used at the site that is the primary concern at this site. The presence of ACM debris and free asbestos structures in site soil have now been documented by sampling and analysis already completed at the site. In fact, asbestos is the only COPC whose presence has been confirmed to date[3]. However, the range of known or suspected historical activities that may have been conducted at the site suggest the possibility that other COPC's may also be present. These include, but are not necessarily limited to:

- Lead from lead-based paint on buildings; automotive shops, gunsmithing, firing range operated by OTI;

- Polychlorinated biphenyls (PCBs) from electrical transformers known to have been historically present at the site;

- Gasoline, diesel, waste oil, and/or petroleum-based solvents from a service station that may have operated at the site, as well as OTI automotive workshops;

- Perchloroethene (Perc) from a dry cleaning facility that may have been operated within the laundry known to have operated at the site;

- Various organic solvents from the automotive, paint, and other mechanical shops that operated at the site; and

- Medical wastes from the reported disposal of wastes that may have been generated during operation of the various medical facilities known to have operated at the site both by the Marines and by OTI

Given the above, one of the secondary objectives of the proposed RI/FS will be to test to confirm or refute the presence of these other COPC's.

4.1.2 Nature and Distribution of COPC's

The locations of the historical buildings formerly present at the North Ridge Estates Site can be defined in a series of historical aerial photographs. Based on further evidence from these photographs (along with supporting evidence from other sources), most of the unsalvaged debris from demolished buildings at the site appears to have been buried in place. Thus, ACM and free asbestos are most likely to be found within and around the footprints of the former buildings at the site. However, a few exceptions to this general rule have been noted and need to be investigated.

There is evidence (Section 3.3) that some materials may have been moved from their original placement during salvage and buried at other locations. There may also have been one or more disposal areas that were actively employed during the period of time that the original Marine Facility or that OTI were in operation. It

[3] A quantity of soil containing elevated lead levels was confirmed at the site and removed in 2004 (Section 3.3).

is also possible that ACM debris (along with free asbestos in the associated soil) has been moved from the original placement (following demolition and disposal) to new locations as a consequence of any excavation and grading performed to prepare the site for construction of the residences that currently exist at the site. Material may also have been moved during subsequent excavation and site improvements conducted by residents themselves.

The historical locations for buried steam pipe have been determined from a series of construction drawings. Based on available information, steam pipe in several locations may have been physically pulled from the ground, locally stripped of insulation, and salvaged. The precise locations where such operations occurred are not currently known. Moreover, it is possible that steam pipe insulation may have been further moved from the original location at which it was first deposited, during excavation and grading performed to prepare the site for construction of the new residences and/or subsequent excavation and grading of individual parcels that may have been conducted by residents themselves.

Although none have been confirmed to be present by sampling and analysis at this time, COPC's other than asbestos are most likely to be found at locations in the immediate vicinity of the historical buildings and facilities where such materials are likely to have been used.

4.2 CONCEPTUAL SITE MODEL

A conceptual site model (CSM) is a summary description of the ways that COPC's present in the various source areas of a site can be released to the environment and be transported to locations where exposure may occur. The CSM thus provides a framework for evaluating the manner in which conditions at the site may pose human health or environmental risks. Typically, this is documented by identifying and characterizing a comprehensive set of exposure pathways for the site.

An exposure pathway is a description of a specific set of mechanisms by which a particular hazardous material can be released to and transported in the environment to locations where it contributes to exposure to a specific population[4]. Thus, exposure pathways necessarily include the following components:

[4] In this context, the term "population" does not necessarily signify only human populations. If the objective of an evaluation also includes the need to assess environmental threats, "population" may also signify specific kinds of flora or fauna.

- a source (e.g. contaminated soil or fill) of chemicals of potential concern (COPC's). For the North Ridge Estates Site, the only COPC confirmed to date is asbestos;

- a mechanism by which COPC's (e.g. asbestos) may be released from each source (e.g. disturbance by natural forces such as wind or disturbance by human activities such as walking over or digging in contaminated material);

- a mechanism (e.g. wind dispersion) by which a COPC may be transported through a specific environmental medium (e.g. air) from a source to a location where exposure may occur (an exposure point);

- the characteristics of the populations, commonly called receptors, that might become exposed at the exposure point; and

- the route of exposure (i.e. the mechanism by which a COPC is taken up into the body from the environment). In the case of asbestos, the primary route of exposure of concern is inhalation.

To be conservative, a CSM typically comprises the set of all conceivable exposure pathways by which exposure can potentially occur at a site, based on the best information available at the time that the CSM is developed. In some cases, this means including pathways that may not currently be operating, but that may have been operating in the past or may operate in the future, given some anticipated change in site conditions. When site conditions are conducive to the presence and operation of all of the defined components of a particular exposure pathway (so that such a pathway can potentially be contributing to exposure), such a pathway is termed "complete." When conditions at a site preclude the presence or operation of one or more components of a particular exposure pathway, such a pathway is termed "incomplete."

Importantly, any CSM initially developed during planning for a site should be considered a work in progress. This is because, as more data are collected during the RI, new COPC's may be discovered and/or new site conditions may be identified that require consideration of additional exposure pathways beyond those originally defined. In some cases, exposure pathways originally thought to be important may also be eliminated.

An initial CSM for the North Ridge Estates Site is presented in Figure 4. Importantly, this initial CSM is designed entirely to identify issues associated with the presence of asbestos, which is the only COPC whose presence has been confirmed to date. Should the presence of other COPC's be identified as the RI progresses, the CSM for the site will be supplemented accordingly.

The initial CSM presented in Figure 4 is also based on the assumption that land use for the site will remain residential. As the RI/FS progresses, if it is determined that alternate land uses need to be considered for the future of the site (such as limiting future land use to recreational), the CSM will be supplemented accordingly.

In Figure 4, the generic components of an exposure pathway are listed across the top of the figure, as headings of columns. Thus, the first column lists sources, the second column lists release mechanisms, the third lists transport media, the fourth lists transport mechanisms, the fifth lists exposure points, and the sixth lists routes of exposure. The next three columns indicate the three classes of receptors to be considered for exposure to asbestos: residents, construction workers, and utility workers. A black dot in a particular row in any of these "receptor" columns indicates that the indicated receptor group is to be considered in association with the exposure pathway described in the corresponding row.

The last two columns of Figure 4 respectively indicate whether particular exposure pathways are complete and, if they are, whether they are to be addressed during the RI/FS process.

As can be seen in Figure 4, the primary source of all asbestos at the site was the various asbestos-containing materials (ACM) employed as construction materials at the site. This includes, but may not be limited to:

- roofing shingles, felts, and mastic;
- cement asbestos board (CAB), or transite, siding;
- floor tiles and mastic;
- aircell insulation for water pipes and other thermal insulation applications; and
- magnesium silicate, or "mag", insulation for steam pipes and boilers.

These materials (and the asbestos contained within) may be released to the environment by natural weathering, by demolition of buildings, and/or by intentional disposal of building components. The latter is potentially important as a release mechanism that is separate from demolition both because it may have occurred in concert with maintenance or repair when the former buildings of the site were actually being used or because, during demolition (in some cases), unsalvageable materials may have been transported to new locations remote from locations where buildings were being demolished and/or steam pipe was being extracted from the ground.

Because asbestos can be released from ACM during weathering, as can be seen in Figure 4, it is possible that such asbestos could ultimately become airborne due to wind and be transported to locations where it might be inhaled. However, this pathway will not be considered further during this RI/FS for two reasons. First, the number of remaining buildings that incorporate ACM components at the site is limited and these buildings are well maintained. Second, as has been shown in the literature (Spurney, 1989), weathering is an extremely slow process that is unlikely to contribute substantially to overall exposure at the site.

As can be seen in Figure 4, the historical demolition of buildings and the disposal of ACM at the North Ridge Estates Site were likely the major mechanisms by which ACM debris was distributed broadly throughout site soils and likely contributed substantially to the introduction of free asbestos structures in the immediate vicinity of the locations where demolition occurred. The dust generated during such activities may also have contributed to historical exposures at the site. However, because demolition and disposal are no longer occurring at the site, the pathway by which these activities contribute to direct exposure is no longer complete. Therefore, it will not be considered further in the current RI/FS.

Once introduced to the soil, ACM debris can continue to contribute to exposure through several mechanisms. First, such debris can be handled directly by site residents (particularly children), which can lead to release of asbestos from the ACM matrix to the air, where it can be inhaled. Another pathway that will be explicitly addressed in this RI/FS involves handling and disturbance of steam pipe insulation by utility workers, if they encounter buried steam pipe during their work. The magnitudes of the exposures potentially associated with these pathways vary as a function of both the type of ACM and how it is handled. As can be seen in Figure 4, this pathway will be addressed explicitly in the RI/FS.

ACM in soil may also release asbestos to the environment when it is disturbed either by human activities or natural degradation processes. In fact (as indicated in Figure 4), the continued, slow degradation of ACM likely supplements the initial reservoir of free asbestos in surrounding soils that may have been introduced during initial demolition and disposal.

Liberation of asbestos from ACM debris (due either to natural processes or disturbance by human activities) may also contribute directly to exposure when liberated asbestos structures become airborne and are transported to locations where they may be inhaled. As indicated in Figure 4, contributions from this pathway will be conservatively addressed in the RI/FS by assuming complete degradation of the ACM that is present in the various source areas and evaluating the corresponding exposure that might occur due to the release and transport of the resulting concentrations of free asbestos in each source. However, while such considerations are important for assessing the long-term potential for exposure, near-term exposures will continue to be driven by release and transport of the existing free asbestos in source soils, which has already been liberated from ACM.

Note, the existing reservoir of free asbestos in a particular source may also be evaluated separately from the ACM in the same source to the extent that there is a need to distinguish among remedial options that address ACM or soil separately from the two combined.

Because free asbestos in surface and subsurface soils potentially contribute to exposure along a different set of pathways, surface and subsurface soil sources will be separately evaluated at the North Ridge Estates Site (Figure 4). Free asbestos in surface soils may be released to the air and contribute to exposure:

- during disturbance of surface soil by any of a range of residential activities. The set of residential activities proposed for consideration in this RI/FS are listed in Table 1;

- during disturbance of surface soil by any of a range of construction-related (or remediation-related) activities. The set of construction-related activities proposed for consideration are listed in Table 1. Note that, when soils are disturbed by construction-related activities, both the construction workers themselves and any neighboring residents can potentially experience exposure; and

- due to disturbance and entrainment by wind.

Asbestos in surface soil may also be tracked into homes on the soles of residents' shoes. Once in the home, free asbestos will become a component of household dust. The asbestos may then become airborne and contribute to indoor exposure when it is disturbed by any of a variety of indoor residential activities. The indoor residential activities proposed for consideration in this RI/FS are listed in Table 1. Note that (as indicated in Figure 4) asbestos structures may also enter or leave a house due to transport between indoor and outdoor air across the shell of the house.

In addition to exposure by inhalation, as indicated in Figure 4, due to intimate contact with soil during at least some residential and construction-related activities, free asbestos may also be passed to the mouth and ingested. As previously indicated (Section 2.1), however, evidence is limited that asbestos is a hazard when ingested and there is no available dose-response factor. Therefore, risks attributable to ingestion of asbestos will not be further addressed.

Free asbestos in subsurface soils may be released to the air and contribute to exposure:

- during disturbance of subsurface soil by any of a range of residential activities. The set of residential activities proposed for consideration in this RI/FS are listed in Table 1; and

- during disturbance of subsurface soil by any of a range of construction-related (or remediation-related) activities. The set of construction-related activities proposed for consideration are listed in Table 1. Note that, when soils are disturbed by construction-related activities, both the construction workers themselves and any neighboring residents can potentially experience exposure.

- Note that disturbance of contaminated subsurface soils by utility workers is one exposure pathway that will be explicitly addressed in this RI/FS.

4.3 PRELIMINARY ASSESSMENT OF RISK

Existing data collected from the site have been employed to assess risks from near-term exposures (see Berman 2003, 2004, 2005a, and 2005b). This has been done primarily to evaluate the need for conducting immediate actions at the site.

Based on the conclusions from these studies:

- each of two general types of asbestos have been identified at the site: chrysotile (a serpentine asbestos) and amphibole asbestos;

- for at least some locations at the site, bounding estimates of asbestos-related risks associated with near-term exposures relating to dust generation from certain residential activities exceed both the range of risks potentially considered acceptable by EPA and the action levels set by the DEQ. Note that the DEQ action levels have been defined as ARAR's for the North Ridge Estates Site; and

- among asbestos types, elevated bounding estimates are driven by the presence of amphibole asbestos despite the observation that this type of asbestos represents less than approximately 3% of all of the asbestos that has been observed to date.

Because amphibole asbestos has been shown to drive risk considerations at the site while having been detected only relatively rarely to date, an early objective of the proposed RI should be to better characterize the overall extent of amphibole asbestos contamination at the site.

4.4 PRELIMINARY IDENTIFICATION OF RESPONSE OBJECTIVES AND OPTIONS

A preliminary list of response objectives and an attendant, preliminary set of remedial options are identified in this section.

4.4.1 Response Objectives

The following, preliminary list of response objectives was developed based on the general objectives for this RI/FS, which were largely articulated in the UAO under which this work is being conducted and are reproduced in Section 2.1**.** These preliminary response objectives are:

- mitigating airborne exposure to asbestos generated in dust from site sources at levels capable of contributing unacceptably to risk; and

- if necessary, mitigating exposure in indoor air to asbestos generated from the re-entrainment of household dust at levels capable of contributing unacceptably to risk.

Importantly, the above list of response objectives are currently focused on issues associated with the presence of asbestos. This is because asbestos is the only COPC whose presence has been confirmed at the site (other than the lead contaminated soil, which has already been addressed). If the presence of other COPC's are confirmed during the RI, than the remedial objectives will be broadened to assure that hazards posed by these other COPC's are also adequately addressed.

4.4.2 Response Options

There is currently no known method for destroying asbestos at less than astronomical cost. Therefore, long-term options for remediating asbestos at the site are largely limited to:

- excavation with offsite burial in an approved landfill;
- excavation with onsite burial in a secure cell; or
- capping in place.

Depending on the extent to which each of the above are applied relative to the extent of contamination ultimately determined, a variety of institutional controls (such as deed restrictions) may also be needed to supplement the remedial options selected for the site.

To address near-term concerns associated with exposure to asbestos, the EPA is currently planning to relocate site residents during the summer months, when conditions are most conducive to creating the highest levels of exposure. Determining the need for additional early actions that may also be required to protect public health in the near term is an additional consideration to be addressed as part of this RI/FS.

5 WORK PLAN RATIONALE

5.1 TECHNICAL APPROACH

Based on the data collected at the site to date, both ACM and free asbestos structures have been observed at multiple locations in soil at the North Ridge Estates Site. Currently, however, neither the precise locations where such contamination exists nor the areal or vertical extent of such locations are known with sufficient precision to support design of effective remediation. In fact, nothing at all is currently known about the distribution of asbestos contamination with depth. Moreover, while it is believed that the locations at which asbestos contamination (both ACM and free asbestos) exist are largely to be found in proximity to the footprints of the historical buildings formerly present at the site, there is evidence suggesting the presence of additional locations where site wastes may have been buried (see Section 3.3). These remain to be investigated and confirmed. In addition, the presence of additional COPC's (other than asbestos), which has been suggested, remains to be confirmed or refuted.

It should also be noted that, due to some questions that remain to be resolved concerning the manner in which site risks have been characterized (see, for example, Berman 2005a), limited and focused laboratory and/or field confirmation studies may also be warranted. Such studies may be helpful because, the greater the confidence that can be placed in the risk estimates, the easier it will be to delineate areas of the site potentially requiring remediation from areas of the site where remediation is unnecessary.

Given the above, the overall approach proposed for this RI/FS is to conduct a phased RI while developing options for remediation as part of the FS. The initial phase of the proposed RI would be focused on answering general questions about the site that are required to complete overall scoping and planning. These are:

- whether the approach used at this site for assessing asbestos-related risks is adequately reliable;
- whether alternate sampling and analysis methods for the determination of asbestos sin soil and bulk materials can be shown sufficiently precise,

accurate, and cost-effective to supplement/replace the primary approach being employed at the site;

- whether it can be confirmed that the extent of amphibole contamination at the site is sufficient to drive risks (as has currently been supposed, see Section 4.3);

- to better identify and refine a preliminary list of response options: whether asbestos contamination over most of the site extends to depths greater than a couple of feet;

- whether asbestos contamination exists at locations other than those associated with the footprints of former buildings; and

- whether other COPC's are present at the site that will need to be addressed during remediation.

Once the initial phase of the proposed RI is completed and a preliminary list of remedial options are identified as part of the proposed FS, the objectives for the final phase of the RI will be defined. In the final phase of the RI, the site will be characterized with sufficient precision to support development, evaluation, and selection among remedial options for the site. The proposed FS will then be completed in a manner suitable for supporting a record of decision.

Importantly, given the large overall size of the site (on the order of 150 acres) and the relative cost of characterization and remediation, defining the nature and extent of contamination at the site with improved precision will facilitate identification, development, evaluation, and selection of more cost-effective remedial options than is currently possible.

5.2 DATA QUALITY OBJECTIVES

The Data Quality Objective (DQO) Process is employed in this section to guide efficient design of the proposed RI. The first steps of the process are applied in detail to complete a preliminary design for the initial phase of the RI and then applied more generally to the final phase of the RI to guide in its conceptualization. A complete, formal design for the initial phase of the RI will be developed by completing the remaining steps of the DQO process as part of the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) for the site. Formal design of the final phase of the RI will be completed pending the results of the initial phase.

The DQO process is a form of systems analysis. It is a tool used to focus the thinking of an investigation planner to assure that all of the considerations necessary to design efficient investigations are systematically addressed. Generally, an efficient investigation is one that precisely generates the type and quality of data that are both necessary and sufficient to address pre-defined issues of concern. Thus, because such data should completely satisfy the objectives of an investigation, collection of additional data would be superfluous.

The seven steps of the DQO process are:

1. State the problem;
2. Identify the decision(s);
3. Identify inputs to the decision(s);
4. Define the study boundaries;
5. Define the decision rule(s);
6. Establish limits on decision errors; and
7. Optimize the study design.

In this work plan, the first two steps of the DQO process are applied to issues of concern so that the efficacy of addressing each issue can be evaluated. If efficacious, as previously indicated, detailed design of the investigation required to address each issue will then be completed by applying the remaining five steps of the DQO process and this will be documented in the SAP and QAPP for the site.

As indicated below, the proposed RI is phased because several issues have been identified that need to be resolved prior to planning the broader, final phase of the RI. In turn, the final phase of the RI will be designed to provide the data necessary to satisfy each of the three objectives that were previously identified for the RI (Section 2.1). Objectives and decisions to be addressed in the initial phase of the RI and the final phase of the RI, respectively, are described separately below.

5.2.1 The Objectives and Decisions to be Addressed During the Initial Phase of the RI

There are two general risk-management objectives that have been identified for the North Ridge Estates Site (Section 2.1). The first objective is the need to mitigate asbestos-related hazards and the second is to mitigate hazards attributable to COPC's other than asbestos that may be present. In both cases, decisions concerning the need for remediation are to be risk based.

Regarding asbestos-related risks, the ultimate goal of the proposed RI/FS is to identify the most cost-effective manner for remediating such risks so that the site can be made useable for its current and designated future land use (assumed to be residential). Therefore, the factors affecting the costs of remediation (for each candidate remedial option) need to be identified and the nature of any site characterization that may be required to inform such costs need to be defined[5].

For each of the candidate remedial options identified for addressing asbestos-related risks (Section 4.4.2), with one exception, costs are a function of:

- the risk-based action level(s) that will be set for delineating areas to be remediated;
- the manner that the risk-based action level will be applied;
- the areal extent of each area to be remediated; and
- the depth to which contamination extends in each area to be remediated.

Note that, for the one exception (the remedial option involving capping in place), costs are a function of only the first three of the factors listed above.

Regarding the first of the above cost factors, the action level that will be applied to identify media requiring remediation will be derived from the results of the BRA. Because some questions have been raised concerning the manner in which risks have been evaluated at this site heretofore (Berman 2005a), prior to planning the final phase of the RI, it would be prudent to address these questions. Therefore, it is proposed that such questions be addressed in the initial phase of the RI. Detailed considerations for addressing questions concerning procedures for supporting risk assessment are addressed below (Section 5.2.1.1).

Regarding the second of the above cost factors, the methods currently employed for sampling and analysis of soil to quantitatively support decisions concerning asbestos-related risks are expensive. However, several less-expensive candidates are available, which may be used to supplement (or even replace) the current methods, if they can be shown to correlate with exposure and risk and if they can be calibrated as site-specific tools. It is therefore proposed that, the adequacy and utility of these candidate methods be evaluated during the initial phase of the RI potentially to expand the range of tools available for implementation during the final phase of the RI. Plans for such an evaluation are described below (Section 5.2.1.2).

[5] Formally, data also need to be collected to support evaluation of such things as the technical feasibility and the overall effectiveness of the various remedial options. However, the nature of the candidate options that are being considered for asbestos (Section 4.4.2) are all likely to be effective and, other than issues relating to cost, are all likely to be feasible. Thus, questions concerning cost are emphasized in the above discussion, although no data needs are intentionally being eliminated from consideration at this stage.

Regarding the last two of the above cost factors, clearly, the greater the resolution with which the site is characterized (both horizontally and vertically), the better the resolution with which soil volumes requiring remediation can be defined. Thus, the greater the resolution by which the site is characterized, the smaller the cleanup costs. However, the greater the resolution by which the site is characterized, the greater the cost for characterization.

Detailed characterization of the site (that is sufficient to define the boundaries of required remediation) will be the focus of the final phase of the RI. However, several issues affecting the planning for such comprehensive characterization remain to be resolved. These are:

- confirming the risk drivers at the site; and

- obtaining a preliminary indication of the depth of contamination over the site.

Regarding the former, the preliminary risk assessments completed to date suggest that the presence of amphibole asbestos drives asbestos-related risks at the site. However, this conclusion is based on an evaluation that is a conservative extrapolation from observation of only a very small number of amphibole structures. Therefore, it would be prudent to confirm that amphibole asbestos is sufficiently ubiquitous at sufficient concentrations to actually drive risks, before committing to a specific strategy for characterizing and remediating the site. The distributions of chrysotile and amphibole asbestos at the site do not necessarily coincide so that strategies for characterizing their distributions may differ. It is therefore proposed that questions regarding risk drivers be addressed in the initial phase of the RI. Detailed considerations for confirming the risk drivers at the site are addressed in Section 5.2.1.3.

The latter of the two issues listed above is important because, although we currently have a preliminary indication of the areal extent of contamination, there are no existing data informing on the potential depth of contamination over the site in general. Before committing to an extensive subsurface sampling campaign, it would be prudent to know how deep contamination potentially extends. It is therefore proposed that such questions be addressed in the initial phase of the RI. Detailed considerations for obtaining a preliminary indication of the depth of contamination are addressed in Section 5.2.1.4.

Regarding the need to eliminate hazards from COPC’s other than asbestos (which is the second risk-management objective for the site), the presence of such substances remains to be confirmed. While there are suggestions that COPC’s other than asbestos may exist at the site, no sampling and analysis has been conducted to confirm or refute their presence. Therefore, before committing substantial resources to an as yet unidentified hazard, it is proposed that questions concerning the presence of any other COPC's be resolved in the initial phase of the RI. Detailed considerations required to conduct an initial search for COPC's are addressed in Section 5.2.1.5.

5.2.1.1 Evaluating the Adequacy of the Current Approach for Supporting Asbestos-Related Risks

As indicated above, the first two steps of the DQO process are applied in this section to support preliminary design of the initial phase of the proposed RI for the North Ridge Estates Site. The five objectives identified above for the initial phase of the RI are each addressed separately. In this section, considerations concerning the adequacy of the current approach for supporting asbestos-related risks are addressed.

Asbestos-related risks attributable to three general categories of exposure have been proposed for evaluation at the North Ridge Estates Site:

- exposures associated with ambient conditions;
- exposures associated with residential or construction-related activities that are performed outdoors; and
- exposures associated with residential activities that are performed indoors.

A detailed list of the specific residential and construction-related activities proposed for evaluation is provided in Table 1.

Of the above, ambient exposures have already been evaluated based on direct measurement of exposure concentrations and (consistent with findings at other, similar sites) have been found to be small (Berman, 2003).

The general approach that has been employed to date for evaluating risks posed by outdoor exposures associated with specific activities at the North Ridge Estates Site is to determine the concentrations of asbestos in source materials using the Modified Elutriator Method (Berman and Kolk, 2000) and modeling exposure from such source concentrations using dust emission and dispersion models that have either been published by the EPA or have been adapted for this study from published EPA models (Berman, 2004 and Berman, 2005a).

Although the above described procedure was demonstrated to be effective over a limited range of conditions in a previous study (Berman, 2000), the efficacy of the overall approach is subject to limitations in the reliability of the models that are available for particular exposure scenarios of interest. This is particularly true of models that had to be adapted (modified).

To address model limitations, highly conservative estimates for certain input parameters were incorporated into the models (especially adapted models) to minimize the chance that exposures would be under-estimated. In addition, the

EPA completed an Activity-Based Sampling Study in 2004 during which airborne asbestos (exposure) concentrations were monitored while conducting simulations of a selected set of dust generating activities performed by residents at the site. Subject to limitations in the data reported for this study[6], results were compared to corresponding modeled estimates to better characterize the degree of uncertainty attributable to the modeling approach.

The EPA study evaluated exposures associated with three scenarios: a child's play scenario, a weed-trimming scenario[7], and a rototilling scenario. This addressed at least two of the four general categories of models previously applied to cover the range of residential activities of interest (Berman 2004 and Berman 2005a). These categories are:

1. a model addressing various modes of transport (including walking, running, bicycling, and ATV riding) across unpaved areas of the site;

2. a model addressing rototilling;

3. a model for loading and dumping of soil that was applied to address child's play and gardening; and

4. a model addressing direct handling of ACM[8].

Results of the comparison between measured and modeled exposure concentrations supported a more detailed analysis of uncertainty and allowed the models to be optimized for the site (Berman 2005a). Among other things, the results suggest that the conservative inputs initially applied to the rototilling model were more than adequate to take into account any limitations in the model.

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[6] There are two limitations to the use of the data from the EPA study: (1) gaps in the formal, written documentation of the procedures employed for sample collection, preparation, analysis, and quality assurance/quality control that need to be filled to facilitate data interpretation; and (2) lack of collection of data allowing discrimination between modeling problems and measurement problems. The first limitation is correctable and the missing information has been requested. The second limitation is not correctable as this was not a design objective of the original EPA study.

[7] Because weed-trimming was not previously modeled, it could not be included in the comparison conducted.

[8] Because there is no EPA model that could be adapted for this pathway, a simple "back-of-the-envelope" model was derived ab initio. As previously indicated (Berman 2003), this model is therefore subject to the greatest uncertainty of all the models applied at the site.

However, the conservative inputs initially applied to the child's play model appear to have been slightly too small to adequately address the overall uncertainty of the model[9]. Both models were then optimized for the site, based on the results from this comparison.

Given both the lack of coverage of the two other general classes of models employed to assess exposure and risk and the potential utility of further evaluating the child's play model (including evaluation of an alternate version of the model), it appears useful to conduct limited additional activity-based sampling to further characterize the uncertainties associated with modeled exposures. It may also prove useful to conduct a bench-scale test to better quantify the uncertainty of the model employed to assess the risks attributable to direct handling of ACM.

It should also be noted that the approach described above for assessing outdoor exposures is also proposed for evaluating exposures associated with indoor activities. However, this requires an additional consideration: identification or development of a suitable method for determining asbestos concentrations in indoor sources. The approach previously applied at the site was developed expeditiously to fill this general need, was not validated, exhibited multiple limitations, and proved capable only of providing qualitative data (Berman, 2005b).

Given these difficulties, limited additional characterization of asbestos concentrations on indoor surfaces may be warranted as part of the final phase of the RI. It may also prove useful (as part of the initial phase of the RI) to evaluate the efficacy of any alternate method (ASTM, 2003) that might be used to characterize indoor concentrations on surfaces and to correlate such measurements against measured indoor, airborne concentrations through dynamic modeling. Assuming that a vacant house is available, such an effort can simply be incorporated as part of the activity-based sampling study described below.

Given the above, there are two general characterization efforts (a laboratory study and an activity-based monitoring study) that need to be evaluated using the DQO process both to determine their efficacy and (if efficacious) to optimize their design.

Regarding the laboratory study, the cost of this effort will be substantially less than $10,000 while the results of the study (if properly designed) will allow estimation of substantially improved uncertainty bounds on exposure and risk

[9] Final determination of this conclusion must await formal confirmation of the depth interval from which the moisture content measurement was derived in the EPA study. Moreover, an older version of the model (which contains an explicit parameter for silt content) has now been identified and is being evaluated to test whether results from this EPA model provide improved agreement over the EPA model previously employed for child's play.

attributed to handling of ACM so that better risk-management decisions can be supported by such estimates. Moreover, given that such a cost will be less than 1% of the cost estimated for characterizing the overall site sufficiently to design final remediation (on the order of $1,000,000) and that improving the bounds on risk estimates for the handling of ACM can potentially reduce the scope of remediation (with a projected range of costs that may be an order of magnitude greater than that estimated for characterization), the utility of conducting the laboratory study appears obvious.

Given the above (which defines the problem as required by the first step of the DQO process), it is proposed that this laboratory study be incorporated into the initial phase of the RI. As required by the second step of the DQO process, the decision to be addressed by such a study is:

> *Whether the modeled exposure estimates derived for the direct handling of ACM adequately bound any actual exposures that may be associated with this pathway (for a reasonable worst case).*

A detailed design for this study will be proposed as part of the Sampling and Analysis Plan (SAP) for the site. The design of the study will also be optimized by applying the remaining steps of the DQO process.

The proposed activity-based sampling study will provide data for better characterizing the uncertainty of the remaining general class of models that was not addressed either by the previous EPA study or by the proposed laboratory study (see above). This will support better confirmation of the exposure pathways that drive risk at the site. Because existing data suggest that the child's play scenario drives overall risk at the site, the proposed study will also provide additional data for further evaluating the original (and alternate) model employed for child's play (under at least one set of conditions distinct from that previously explored by EPA).

Overall, the proposed study will provide the data needed to optimize and validate site-specific modeling so that site risks can be better estimated with improved confidence. Correspondingly, this will improve the confidence that can be placed in the site-specific target levels that will be derived during the baseline risk assessment and will be used to define risk-based cleanup at the site.

The detailed design for the proposed activity-based sampling study will be developed by applying the last five steps of the DQO process and will be presented in the SAP for the site. However, the general decisions envisioned for the study are defined here to facilitate evaluation of the overall efficacy for completing this study. As currently envisioned, the decisions to be addressed in the proposed study are:

1. *whether airborne (exposure) concentrations of asbestos generated while loading/dumping of a bucket (to simulate child's play) can be predicted to within pre-defined confidence bounds using appropriate bulk measurements*[10]*;*

2. *whether airborne (exposure) concentrations of asbestos generated while running, bicycling, or loading/dumping of a bucket (simulating child's play) can be adequately bounded by modeling in the manner already applied at the site (using appropriate bulk measurements as inputs)*[11]*;*

3. *whether factors such as moisture content, silt content, and asbestos content are adequately addressed by the available models; and*

4. *to the extent that limitations are encountered, whether such problems are associated primarily with model limitations or with the bulk asbestos measurements.*

Note that defining the required decisions satisfies the second step of the DQO process.

Note further that, if the first of the above-listed decisions cannot be achieved with the indicated model for child's play, the child's play model will be further optimized by better fitting it to the broader range of activity-specific data that will be generated from the new study and the model will be evaluated to determine whether it can at least be used to adequately bound risks in the manner indicated by the second of the above-listed decisions.

Given the relatively limited variation observed across replicate simulations in the EPA study and the limited number of conditions over which it is anticipated that specific activities will be evaluated, a rough estimate for the cost of the field and laboratory work for the proposed simulation study is approximately $100,000. At the same time, the results of the study will substantially improve the degree of confidence that can be placed in the risk estimates that are developed for the site which will facilitate support for improved risk-management decisions.

The cost of the activity-based monitoring study is projected to be approximately 10% of the cost estimated for characterizing the overall site sufficiently to design final remediation (on the order of $1,000,000) but only approximately 1% of the

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[10] As previously indicated, an alternate version of the model previously employed for child's play (that explicitly accounts for silt content) will also be evaluated.

[11] Because the general EPA model for transport on unpaved roads is adapted (modified) for application to running and bicycling, it will only likely be possible to demonstrate the adequacy of the modifications for bounding (rather than directly predicting) exposure. An insufficient number of simulations is planned to allow full evaluation of the effects of the modifications. However, if the effects of the modifications prove to be small, they may be simplified or eliminated and the original model may then be applied directly to predict exposure.

range of costs that may be required for remediation. At the same time, improving the risk bounds that may be used to derive target action levels could potentially reduce the extent of required remediation substantially (at least on the order of several percent). This indicates that the proposed activity-based monitoring study would be efficacious.

5.2.1.2 Evaluating the Viability of Candidate Methods for Supplementing Characterization of the Nature and Extent of Asbestos Contamination

The methods currently employed for sampling and analysis of soil to quantitatively support decisions concerning asbestos-related risks are expensive. These are based on the Modified Elutriator Method (Berman and Kolk, 2000). However, several candidate alternatives are available, which are substantially less expensive than the current method. Such alternatives may be used to supplement (or even replace) the current method, if they can be shown to correlate with the existing method and if they can be calibrated as site-specific tools. Among the alternatives being considered for specific applications are:

- formalized evaluation of the relationship between locations of historical buildings and areas of asbestos contamination as a surrogate for sampling and analysis;

- formalized visual inspection to assess the ACM content of surface soil as a surrogate for sampling and analysis for the determination of asbestos;

- field determination of the mass fraction of ACM in surface or sub-surface soil as a surrogate for sampling and analysis for the determination of asbestos; and/or

- analysis for determination of asbestos by polarized light microscopy (PLM) following sample preparation using a Standard Operating Procedure designed specifically for soil.

The possibility of evaluating (and potentially exploiting) correlations between different size ranges of structures observed by TEM or between TEM measurements derived using the Modified Elutriator Method and a TEM measurement derived using a less expensive method may also be considered. It may also be useful to consider the possibility of coupling elutriation (as described in the Modified Elutriator Method) with analysis by phase contrast microscopy (PCM).

Note that adding multiple, candidate methods to search for site-specific correlations with the base method (i.e. the Modified Elutriator Method) adds only inconsequential cost to the overall cost of this study. This is because the primary cost driver for this study will be the initial analysis of samples by the base method.

The best approach for evaluating the utility of these options is to test both informally and formally for correlations across the methods. This can be accomplished by collecting a series of samples at the site from locations that cover a broad range of site conditions and to prepare and analyze each such sample using each of the candidate procedures. The degree of correlations (or of bounding) that can be accomplished across methods can then be assessed.

Based on a rough estimate of the number of samples and analyses that might be required to validate any of these alternate procedures for site-specific application, it is estimated that a study designed to test the utility of these options at the North Ridge Estates Site would be on the order of $100,000. Although this cost approaches 10% of the cost estimated for characterizing the overall site sufficiently to design final remediation (on the order of $1,000,000), should it be possible to demonstrate even marginal utility for any of these alternate methods, it could result in substantial savings for the overall cost of characterization that might otherwise be required at the site. Therefore, although the probability of success for this effort cannot be defined at this time, it is likely to be sufficiently high to make this study cost-effective. Moreover, as indicated in the following sections, any study developed to address the issues discussed here could be modified at minimal additional cost to address the issues considered in the remaining sections of this Section. Therefore, the detailed design for such a study will be developed and proposed as part of the proposed SAP for the site.

5.2.1.3 Confirming Risk Drivers

Regarding the need to confirm risk drivers, the preliminary risk assessments completed to date suggest that the presence of amphibole asbestos drives asbestos-related risks at the site. However, this conclusion is based on an evaluation that is a conservative extrapolation from observation of only a very small number of amphibole structures. Therefore, it would be prudent to confirm that amphibole asbestos is sufficiently ubiquitous at sufficient concentrations to actually drive risks, before committing to a specific strategy for characterizing and remediating the site.

The best option for developing data to support improved determination of the occurrence of amphibole asbestos at the site is to re-analyze a selected set of existing samples at improved sensitivity. Such a data set would need to represent large areas of the site and there are two, candidate sample sets that satisfy this requirement: the set of composite samples collected by PBS in late 2003 to represent average conditions across the site as a whole and the set of composite samples collected by EPA in early 2004 to represent conservative estimates of exposure potentially experienced by residents of specific, individual properties (parcels) at the site (Berman 2004).

Based on the results of analyses already completed on the PBS and EPA sample sets, the samples exhibit largely comparable contaminant concentrations (see Berman 2004) so that they are also likely to provide comparable information regarding the extent of amphibole asbestos contamination should either set be re-analyzed at improved sensitivity. Nevertheless, the EPA sample set is proposed for re-analysis because this data set presents the additional advantage of representing conservative estimates of parcel-specific exposure conditions at the site. Selection of this set also provides the opportunity for completing analysis of all of the samples in this set (including those not previously analyzed).

Given that the cost of the re-analysis effort (on the order of $25,000) is inconsequential relative to the likely costs for characterizing the overall site sufficiently to design final remediation (on the order of $1,000,000), the cost-effectiveness of this effort appears obvious. Thus, detailed plans for completing the re-analysis will be provided in the proposed SAP for the site.

5.2.1.4 Obtaining a Preliminary Indication of the Distribution of Asbestos Contamination with Depth

The utility of obtaining even minimal advanced knowledge concerning the general distribution of asbestos contamination with depth seems obvious. Moreover, when coupled with the ability to obtain such information as a simple design modification to the effort described in Section 5.2.1.2, so that the cost for obtaining this information is essentially zero, incorporating this effort into the initial phase of the RI is clearly warranted. Thus, a detailed design for obtaining the required data will be incorporated into the proposed SAP for the site.

5.2.1.5 Searching to Confirm the Presence of COPC’s Other than Asbestos

This can best be accomplished in two steps. First it is proposed that the evaluation of historical records continue so that the presence of structures, facilities, or equipment from which COPC’s (other than asbestos) are suspected to have been released can be confirmed and, if confirmed, the precise locations of such structures, facilities, or equipment can be determined.

Second, confirmation that a release of any such COPC’s historically occurred could then be evaluated by collecting a small number of samples from appropriate locations and analyzing such samples for determination of each of the suspected COPC’s appropriate for the location sampled. This exercise will be required as part of the RI to close issues. Therefore, to the extent that a set of locations requiring investigation can be identified sufficiently in advance of the due date for the proposed SAP, a detailed plan for completing the search for COPC’s (other than asbestos) will be included in the proposed SAP. Moreover, any additional sampling needs that may be defined after the due date for the proposed SAP (which may continue to be identified until the final report on site background and history is submitted and approved), will be addressed in the revised SAP that will be issued to document design of the final phase of the RI (pending completion of the first phase).

5.2.2 Objectives, Decisions, and General Considerations for Designing the Final Phase of the RI

As previously indicated (Section 2.1), the objectives for the final phase are to provide data of known quality that are sufficient to:

- fill data gaps to support completion of the baseline risk assessment (BRA);
- support identification of remedial objectives and the attendant remedial options for addressing them; and
- support an FS that includes development, evaluation, comparison, and selection among remedial options along with design of a final remedy (based on the selected option) that achieves the overall risk-management objectives for the site.

Once the initial phase of the RI is completed so that:

- the set of tools available for use in characterizing the site is defined;
- the risk drivers for the site are adequately identified;
- a general understanding of the distribution of asbestos contamination with depth has been developed; and
- to the extent possible, any COPC's (other than asbestos) that may be present at the site are identified;

it will be possible to develop a plan for full characterization of the site under the final phase of the RI. This will be accomplished by applying the DQO process to formalize and optimize the design of the investigation. Moreover, the optimal resolution at which it makes sense to study the site (to support decisions concerning the nature and extent of required remediation) will be evaluated by comparing the relative costs for characterizing the site at defined resolution against the unit cost for remediating each unit cell for which sufficient characterization will have been performed to support a decision concerning the need for remediation.

6 RI/FS TASKS

This section summarizes the tasks to be completed under the UAO.

6.1 OVERVIEW

The sequence and numbering of tasks presented below preserve the organization of tasks defined in the UAO. Thus, tasks are grouped by general categories of work, rather than presented chronologically.

6.2 TASK 1: CONDUCT PROJECT PLANNING AND SUPPORT ACTIVITIES

Project planning activities that have been conducted to-date have included ongoing compilation of new data, review of newly obtained historical information (aerial photographs, historic documents, etc.) and a site visit of the Respondents' team members.

Meetings and telephone conference calls have been conducted between the Respondents' team and key EPA/DEQ personnel, to discuss the project objectives, potential sampling and analytical work that may be conducted, preliminary remedial action objectives and technologies, discussion of federal and state ARARs and methodology for meeting those requirements.

6.2.1 Subtask 1.1: Complete a Health and Safety Plan

The Health and Safety Plan has been completed and submitted to the EPA/DEQ. The Plan addresses known site hazards which primarily relate to asbestos exposure, but include avoidance of physical hazards, e.g. construction debris. The Plan allows for the discovery of non-asbestos hazards at the site, through a process of stopping work, identifying the hazard and implementing the appropriate personnel safety measures before continuing.

6.2.2 Subtask 1.2: Conduct Initial Meeting and Site Visit with EPA

A project scoping meeting was conducted on May 18, 2005, between the Respondents' team members and key personnel representing the EPA and the Oregon DEQ.

It was agreed that the Site Visit would be postponed until some later date.

6.2.3 Subtask 1.3: Complete RI/FS Work Plan

This document is the RI/FS Work Plan, and includes a description of the site and physical setting, a conceptual site model, a work plan rationale and tasks to be completed under the RI/FS.

6.2.4 Subtask 1.4: Complete Sampling and Analysis Plan

The Sampling and Analysis Plan (SAP) will present a detailed strategy for field investigations, standard operating procedures for all sample location selection, collection, handling, transport and laboratory analysis.

Given the need to confirm certain features of the site and to evaluate the utility of certain candidate procedures that may be employed in site characterization prior to completing a plan for detailed characterization of the site, the proposed RI for the site has been divided into two phases: an initial phase and a final phase.

The detailed strategy for sampling and analysis required to satisfy the objectives of the initial phase of the RI will be optimized by applying the DQO process and presented in the proposed SAP. Once the initial phase is completed and the results can be applied to further planning, the detailed plan for the final phase (which will be conducted to address the site-specific objectives identified in Section 2.1) will be optimized by applying the DQO process and presented in a supplement to the initial SAP.

6.2.5 Subtask 1.5: Complete Quality Assurance Project Plan

The Quality Assurance Project Plan (QAPP) will present the general rationale for sampling and analysis at the site, define quality objectives for all analyses to be performed and data to be developed, describe procedures to be employed for data acquisition and management, define procedures to be used for validating data and evaluating data useability, and include copies of all methods and standard operating procedures (SOP's) to be employed for sampling and analysis at the site.

6.2.6 Subtask 1.6: Complete Site Background Data Report

This report will compile all existing information that relates to the types and locations of hazardous materials used at the Site. This includes available federal, state and local agency file information; historic aerial photographs, maps and documents; previous site investigations, historic records pertinent to evaluation of cultural resources, etc.

To the extent that information from this study will help inform subsequent field investigations, the SAP and QAPP will be modified.

6.3 TASK 2: PROVIDE SUPPORT FOR COMMUNITY RELATIONS

6.3.1 Community Relations Plan

The EPA will prepare a Community Relations Plan that documents the history of community relations regarding the site, and highlights the issues of community concern. As requested by the EPA, the Respondents' team will provide information and participate in the preparation of information intended for dissemination to the public. At the discretion of the RPM, team members may participate in community meetings.

6.3.2 Technical Assistance Plan

The Respondents' team will prepare a Technical Assistance Plan, that will describe the funding and administration of up to $50,000 of the Respondents' funds to be used by a qualifying community group. That group would provide technical expertise to the North Ridge Estates property owners as well as the larger Klamath Falls community.

6.4 TASK 3: CONDUCT FIELD INVESTIGATION

6.4.1 Subtask 3.1 Complete Phase 1 Activities

The plan for the initial phase of the RI will be implemented under this task. The objectives for this initial phase are identified in Section 5.1, which are to provide data of sufficient quality to:

- support evaluation of the adequacy of the current approach for assessing asbestos-related risks;
- support evaluation of the viability of candidate methods for supplementing characterization of the nature and extent of asbestos contamination;
- confirm risk drivers (i.e. confirm that the distribution of amphibole asbestos at the site is sufficient to drive asbestos-related risks);
- support determination of the general distribution of asbestos contamination with depth; and
- confirm or refute the putative presence of COPC's other than asbestos at the site.

The field and laboratory activities that have been proposed to satisfy the above objectives are summarized in the following sections.

6.4.1.1 Conduct an activity-based sampling study and supplemental laboratory study

The proposed activity-based sampling study will focus on evaluating the relationship between measured and modeled exposures associated with child's play (i.e. loading and dumping buckets of soil), running over contaminated ground, and bicycling over contaminated ground. The supplemental laboratory study will focus on confirming the values for input parameters to the model for assessing exposure attributable to the direct handling of ACM.

6.4.1.2 Conduct sampling and analysis to support evaluation of optional methods.

Under this activity, field samples will be collected from a variety of locations from the site that represent a broad range of site conditions. The locations from which the samples are collected will also be subjected to a variety of field procedures to evaluate their utility for predicting the asbestos content of the samples collected. The samples will then be subjected to analysis by the Modified Elutriator Method and other candidate methods. Results from all of the laboratory and field work will then be evaluated to test for useful correlations or bounding relationships that may confirm the reliability of at least some of the candidate procedures to supplement characterization of the distribution of asbestos at the site, which will otherwise be conducted primarily using the Modified Elutriator Method.

Field characterization procedures to be evaluated include: a procedure for visual assessment of ACM concentrations, a procedure for field determination of ACM mass concentration, and reliance on historical information and other visual cues. Alternate analytical methods for the determination of asbestos that may be evaluated in the laboratory potentially include: a PLM-based method, correlations between size ranges of asbestos structures determined by TEM, and TEM analysis coupled with an alternate procedure to the elutriator for preparing soil samples.

6.4.1.3 Re-analyze parcel-specific composite samples.

The existing soil composite samples collected by the EPA in 2003 will be re-analyzed at improved sensitivity to better assess the distribution of amphibole asbestos at the site.

6.4.1.4 Conduct sampling and analysis to support determination of the general distribution of asbestos contamination with depth

This will be accomplished by selecting a combination of surface and sub-surface sampling locations as part of the effort described in Section 6.4.1.2 above.

6.4.1.5 Search for COPC's other than asbestos

In addition, investigation will be conducted to evaluate the potential for non-asbestos COPC's to exist at the Site. Based on the findings of the Site Background Data Report, areas of the Site at high risk of subsurface contamination from chemical releases, e.g. the former service station, will be evaluated using a combination of field assessment, soil sampling and analysis and potential geophysical survey methodology.

6.4.2 Subtask 3.2: Complete a Supplemental SAP/QAPP for the Final Phase of the RI

Once results from the initial phase of the RI become available, the SAP and QAPP for the site will be supplemented to complete planning and a detailed design for the final phase of the proposed RI.

6.4.3 Subtask 3.3 Conduct Phase 2 Sampling Activities

Once the supplemental SAP is approved, field and laboratory activities proposed for the final phase of the RI will be implemented. Activities to be conducted during the final phase of the RI will be adequate for satisfying the overall objectives of the RI that were defined in Section 2.1.

6.5 TASK 4: COMPLETE LABORATORY ANALYSIS OF SAMPLES

6.5.1 Subtask 4.1: Complete Sample Analysis

Laboratory analysis of samples from the North Ridge Estates Site will be implemented in close coordination with the field work. Samples will be handled, prepared, and analyzed in the laboratory in the manner defined by the methods and SOP's incorporated into the site QAPP.

6.5.2 Subtask 4.2: Complete Data Validation

Once a complete set of data become available for each of the distinct field activities that are defined in the subsections of Section 6.4.1, the data will be evaluated in the manner to be described in the site QAPP both to validate the data and to define its overall useability.

6.6 TASK 5: EVALUATE DATA

Once a complete data set from each distinct field activity has been validated and its useability defined, the data will be interpreted to satisfy the objectives for which each data set was designed to address.

Documentation for raw data will be provided to EPA along with the summary tables and discussion that will be produced as each data set is interpreted. Except to the extent not provided by the laboratory, raw data and all data summaries will be preserved and provided to EPA in electronic format.

6.7 TASK 6: ASSESS SITE RISKS

Both a screening risk assessment and a baseline risk assessment are to be completed under this task.

6.7.1 Subtask 6.1: Complete Screening Risk Assessment

A screening risk assessment (based on data that exist as of the start of the RI/FS process) will first be completed under this task. The screening risk assessment will be developed by integrating the components previously reported in the final air report (Berman, 2003), the soil report (Berman, 2004), the simulation report (Berman, 2005a), which will first be revised to address EPA comments, and the dust report (Berman, 2005b), which is also being revised to address EPA comments. The screening risk assessment will also address exposure associated with air entrainment of dust from contaminated soils due to wind, which is an exposure pathway that has not been previously documented.

Importantly, although the data used to support the screening risk assessment were designed primarily to support assessment of risks attributable to near-term exposures at the site (to evaluate the need for immediate actions), implications concerning risks associated with long-term exposure will also be discussed. However, because detailed consideration of the affects of long-term exposures at the site requires characterization of the site at higher resolution than is currently available, such detailed analysis will be postponed until the baseline risk assessment is completed.

6.7.2 Subtask 6.2: Complete Baseline Risk Assessment

A baseline risk assessment (BRA) for the North Ridge Estates Site will be developed once the data from the final phase of the RI become available. As previously indicated, the BRA will address risks attributable to exposures associated with ambient conditions, exposures associated with residential and construction-related activities conducted outside at the site, and exposures associated with residential activities conducted inside of their homes. The complete set of exposure pathways to be considered in the BRA are highlighted in Figure 4 with the specific types of activities to be addressed listed in Table 1.

Subject to approval by EPA, the results of the BRA will also be used to derive target action levels for site soils. The specific manner in which such targets are to be applied at the site will also be defined. These procedures will then be used to delineate areas of the site requiring remediation Importantly, it is anticipated that such a determination will be based primarily (if not exclusively) on the characterization data that will have been collected as part of the final phase of the RI.

Both the range of risk targets defined in EPA regulations and the risk targets defined is ODEQ regulations (which are incorporated into this process as ARAR's) will be evaluated in this risk assessment. Because the State regulations allow for use of probabilistic risks assessment methods (as opposed to deterministic methods) and because such methods provide for increased flexibility in achieving state targets, use of probabilistic methods will be considered for the BRA. However, to assure that such methods can be applied in a manner that will satisfy both State and Federal regulators, the overall approach for conducting such an assessment will be documented formally as part of the supplemental SAP so that agreement on the approach will be obtained prior to its implementation. Some of the detailed considerations to be addressed in any plan for a probabilistic risk assessment include the following:

- first, to assure the reliability of the calculations, support will be obtained from an established statistician with impeccable credentials;

- second, given that the greatest source of controversy associated with conducting a probabilistic risk assessment derives from the manner in which the characteristics of distributions are chosen for certain input parameters, the following priorities will be adopted for deriving distributions;
    - to the extent that the characteristics of the distributions can be directly and reasonably derived from site data, this will be the approach adopted;
    - for parameters that are derived from the literature or from other non-site sources (such as meteorological data), robust data sets will be sought to establish the characteristics of the distributions;
    - for those parameters not associated with robust data sets, but for which clear and consistent literature recommendations on the nature of their distributions exist, such recommendations will be followed; and
    - finally, for parameters for which none of the above approaches are available (and for which no other formalized approach can be identified for defining a reliable distribution), the value for such parameters will be fixed at an agreed, conservative value (which would render the effect of such a parameter equivalent to the effect that it has in a deterministic risk assessment);

- a detailed sensitivity analysis will also be conducted to identify and eliminate situations in which uncertain distributions contribute unduly to the outcome of the overall analysis.

6.8 TASK 7: CONDUCT TREATABILITY STUDIES

As noted above, there are no cost-effective or reasonable methods for “treatment” of asbestos. Therefore, it is assumed that no Treatability Study will be conducted regarding asbestos.

If other COPC’s are identified at levels that warrant remediation and, if options for remediating such COPC’s warrant evaluation of treatment alternatives, plans for conducting such treatability studies will be developed at that time.

If treatability studies are conducted, a memorandum documenting the results and recommendations will be developed and submitted at the completion of the analysis of the data from the treatability study.

6.9 TASK 8: COMPLETE REMEDIAL INVESTIGATION REPORT

Once the final phase of the RI is completed, the results have been incorporated into a BRA, and the BRA is approved, a remedial investigation report will be developed and submitted for review and approval. The initial draft of the RI report will be submitted 30 days after the BRA is approved.

6.10 TASK 9: DEVELOP AND SCREEN REMEDIAL ALTERNATIVES

Preliminary development and screening of remedial alternatives that address asbestos contamination has already begun. As soon as there is agreement on a final list of COPC's (other than asbestos) that are present and need to be addressed at the site, a preliminary list of options for addressing the nature and extent of the full suite of COPC's will be identified and presented for discussion.

Once the RI report is approved, the data will be employed to complete development and preliminary design of a full suite of remedial options that will need to be considered for the site. Such options will then be screened based on the three screening criteria defined in relevant guidance (USEPA, 1988).

Results from the screening of remedial alternatives will be summarized in a screening memorandum to be submitted to EPA.

6.11 TASK 10: CONDUCT DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

Immediately after screening of remedial alternatives is completed, surviving options will be subjected to a detailed evaluation and comparison based on the nine criteria that have been established for conducting such comparisons (USEPA, 1988). Within 30 days following the initial memorandum on screening of remedial alternatives, a report documenting the detailed evaluation and comparison will be developed and submitted to EPA.

6.12 TASK 11: COMPLETE THE FEASIBILITY STUDY REPORT

Within four months after the report documenting the detailed evaluation and comparison of remedial alternatives is submitted to the agency, a draft Feasibility Study report will be submitted. The report will document the development, screening, detailed evaluation, and preliminary design of favored remedial options, and will include an Alternatives Analysis for Institutional Controls and Screening.

6.13 TASK 12: PROVIDE OTHER REQUIRED SUPPORT

As other support required are identified by the EPA, the RI/FS team will discuss with EPA staff the nature of such needs and procedures that can be implemented to provide the required support.

7 COSTS AND KEY ASSUMPTIONS

Project Scoping, Planning	$ 7,000
Site Health and Safety Plan	$ 4,000
RI/FS Work Plan	$ 30,000
Technical Assistance Plan	$ 4,000
Sampling and Analysis Plan Quality Assurance Project Plan	$ 24,000 $ 24,000
Site Background Data Report	$ 14,000
Screening Risk Assessment	$ 36,000
Field Investigation – Phase 1	$ 300,000
Submit Revised SAP	$ 12,000
Field Investigation – Phase 2	$ 600,000
Baseline Risk Assessment	$ 42,000
Draft RI Report	$ 30,000
Treatability Studies	$ 10,000 if necessary
Memorandum on Remedial Action Objectives	$ 3,000
Memorandum on Development and Screening of Alternatives	$ 3,000
Comparative Analysis	$ 18,000
Draft Feasibility Study Report (includes Alternatives Analysis for Institutional Controls and Screening)	$ 32,000
Progress Reports (18) Progress Meetings (6) Public Meetings (6)	$ 40,000
Peer Review Presentations, Meetings	$ 15,000
Total Estimated Cost:	$ 1,250,000

The cost for Phase 1 assumes no more than $25,000 to search for other COPC's. It also assumes no more than $25,000 to check locations outside of the main portion of the site for the presence of asbestos.

The cost for Phase 2 assumes that at least 60% of the site will be shown not to require detailed characterization because cheaper methods will be sufficient to either indicate remediation is required or eliminate such areas from requiring remediation. It also assumes that no major additions to the approximately 150 acres of the main part of the site will be required due to discoveries concerning asbestos in other locations.

Costs are estimated to +/- 20% in general with larger uncertainties associated with the field work.

8 SCHEDULE

Effective Date of the UAO	April 8, 2005
Site Health and Safety Plan	May 8, 2005 *(Sunday; delivered on Monday, May 9, 2005)*
Scoping Meeting between Respondents' Technical Team and EPA/DEQ Technical Team	May 18, 2005
RI/FS Work Plan	June 7, 2005
Technical Assistance Plan	June 24, 2005
Sampling and Analysis Plan Quality Assurance Project Plan	July 7, 2005
Site Background Data Report	July 17, 2005 *(Sunday; delivery by Monday, July 18, 2005)*
Screening Risk Assessment	August 8, 2005[12]
Field Investigation – Phase 1	Commence within 14 days after approval of the SAP/QAPP
Submit Revised SAP	14 days after receipt of validated data from Phase 1
Field Investigation – Phase 2	Commence within 14 days after approval of Revised SAP
Baseline Risk Assessment	30 days after receipt of validated data from Phase 2
Draft RI Report	30 days after approval of the Baseline Risk Assessment
Treatability Studies	*(Determined to not be necessary for asbestos)*
Memorandum on Remedial Action Objectives	30 days after receipt of validated data from Phase 1
Memorandum on Development and Screening of Alternatives	14 days after receipt of validated data from Phase 2
Report on Comparative Analysis and Presentation	Report: 30 days after Memo on Development & Screening Of Alternatives; Presentation: 30 days after Report
Draft Feasibility Study Report (includes Alternatives Analysis for Institutional Controls and Screening)	Within 4 months of the Presentation on Comparative Analysis

[12] Pending approval by EPA.

9 PROJECT MANAGEMENT

9.1 STAFFING

Dulcy Berri, RG, PBS Engineering and Environmental, is the Respondents' Project Coordinator and holds overall responsibility for the project. Other key team members include Dr. D. Wayne Berman, Aeolus, Inc., Technical Project Manager; Jeff Heeren, PBS Engineering and Environmental, Field Project Manager.

9.2 SUPPORT

The team will be supported by additional field and technical staff at PBS Engineering and Environmental and Aeolus, Inc., as appropriate; and by subcontractors as necessary to the scope of work (see below).

9.3 COORDINATION AND COMMUNICATION

The Project Coordinator will work closely with Alan Goodman, EPA's Remedial Project Manager (RPM), and Cliff Walkey, Oregon DEQ Project Manager (PM), and their representatives, to ensure communication of deliverables, scheduling, findings.

Progress Reports. As required by the UAO, the Project Coordinator will provide the RPM with monthly Progress Reports describing actions taken to comply with the Order in the past month, as well as actions planned in the next two months. At this time, one Progress Report dated May 10, 2005, has been submitted.

Meetings. Prior to meetings, the Project Coordinator will provide the RPM and DEQ PM with a proposed meeting agenda, schedule and list of attendees; and will provide the RPM and DEQ PM with a followup list of action items agreed upon by each party, and timeline for completion. At this time, one Scoping Meeting was held on May 18, 2005, and was followed by an email from the Project Coordinator stating Action Items.

Data Management. All deliverables required by the UAO will be provided to the EPA RPM via electronic copy (email, compact disk or ftp website), as well as 3 complete hard copies; and to the DEQ PM via electronic copy and 2 complete hard copies. Such copies of laboratory reports will be submitted as soon as available from the laboratory.

Subcontractors. When work activities involve the use of subcontractors, the Project Coordinator will review with the RPM that contractor's qualifications to perform the work, in advance of conducting the work.

A preliminary list of contractors that may potentially be used, follows:

-**EMS**
Pasadena, CA
(air, soil, bulk testing for asbestos)

-**NVL**
Seattle, WA
(air, soil, bulk testing for asbestos)

-**ESL, Inc.**
Portland, OR
(soil, water testing for physical or chemical quality)

-**RMCAT Environmental**
Portland, OR
(asbestos abatement company; heavy equipment operators)

-**Alpine Abatement**
Bend, OR
(asbestos abatement company)

-**GeoPotential, Inc.**
Portland, OR
(geophysical survey)

10 REFERENCES

Aerial Photograph, Site Vicinity, 7/22/1970, ODOT Geometronics office.

American Society for Testing and Materials – ASTM. (2003). *Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading*. D 5755 - 03.

Bercot, M.E. (1979), Letter to Mark Hooper, US EPA, regarding plan for disposal of asbestos waste, (date unclear), 1979.

Berman, D.W. (2000) “Asbestos Measurement in Soils and Bulk Materials: Sensitivity, Precision, and Interpretation -- You *Can* Have It All.” in *Advances in Environmental Measurement Methods for Asbestos, ASTM STP 1342,* M.E. Beard, H.L. Rook, Eds., American Society for Testing and Materials. Pp. 70-89.

Berman, D.W. (2003) *Preliminary Air Sampling Results for the North Ridge Estates Site, Klamath Falls (Week 3).* Submitted for U.S.EPA review and approval, October 20.

Berman, D.W. (2004), *Final Draft Soil Sampling Results and Preliminary Risk Assessment for the North Ridge Estates Site, Klamath Falls, Oregon.* July.

Berman, D.W. (2005a). *Evaluation of the Implications of Airborne Asbestos Exposure Concentrations Observed During Simulation of a Selected Set of Common, Outdoor Residential Activities Conducted at the North Ridge Estates Site, Klamath Falls, Oregon.* Revised version incorporating responses to EPA and ODEQ comments in preparation.

Berman, D.W. (2005b), *Evaluating Exposure and Risk to Household Residents From Air and Screening Dust Sampling.* Revised version incorporating responses to EPA and ODEQ comments, in preparation.

Berman, D. Wayne, and Kolk, A.J. 2000, *Draft: Modified Elutriator Method for the Determination of Asbestos in Soils and Bulk Materials, Revision 1.* Submitted to the US EPA, Region 8, May 23.

Cooperrider, A., Garrett, R., *Klamath/Central Pacific Coast Ecoregion Restoration Strategy*, US Fish and Wildlife Service, Sept. 30, 1998

Gardenhire, J.R., 1993, Memorandum for Files, Trip Report from DERP-FUDS Preliminary Inspection of Marine Recuperations Barracks, April 13, 1993.

Mullin, C., and Patel, Y. (1991) Drinking Water Criteria Document for Asbestos (Final Draft). U.S. Environmental Protection Agency, Washington, D.C., EPA/600/X-84/199-1 (NTIS PB86118262).

Natural Resources Conservation Service (NRCS) (formerly Soil Conservation Service), 1985, Soil Survey of Klamath County, Oregon, Southern Part.

Oregon Department of Health Services (ODHS), 2003?, *Public Health Consultation, Final Release, North Ridge Estates,* Superfund Health Investigation and Education Program.

Oregon Department of Water Resources (DWR), 2005, Online Water Well Logs, http://www.wrd.state.or.us

Oregon Historical County Records Guide, Klamath County, Oregon: http://arcweb.sos.state.or.us/county/cpklamathhome.html

PBS Engineering and Environmental, 2004a, *Report of Surficial Removal and Burial Location Actions.* Submitted to USEPA, Region 10, Feb. 4, 2004.

PBS Engineering and Environmental, 2004b, *Burial Pile Stabilization Report*. Submitted to USEPA, Region 10, Nov. 19, 2004.

Spurny, K.R., (1989) "On the Release of Asbestos Fibers from Weathered and Corroded Asbestos Cement Products." *Environmental Research, Vol. 48, pp. 100-116*.

Stevens & Thompson, (1958), *Report and Survey of the Oregon Technical Institute.*

U.S. Environmental Protection Agency, (1986). *Airborne Asbestos Health Assessment Update.* Report 600/8-84-003F, U.S. EPA.

U.S. Environmental Protection Agency, (1988). *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, EPA/540/G-89-004, October 1988.

USGS Whiteline Reservoir 7.5 minute topographic quadrangle map, photorevised 1985.

TABLE 1.
RESIDENTIAL AND WORKER ACTIVITIES TO BE CONSIDERED FOR CONTRIBUTIONS TO EXPOSURE AND RISK AT THE NORTH RIDGE ESTATES SITE KLAMATH FALLS, OREGON

Residential Pathways

Outdoor Activities

- Walking
- Running
- Bicycling
- Rototilling
- ATV Riding
- Horseback Riding
- Gardening
- Playing in Soil
- Combined Gardening and Play
- Playing with ACM

Indoor Activities

- Quiescent - No Activities
- Sitting on Floors or Upholstery
- Walking or Playing on Floor
- Dusting
- Vacuuming

Worker Activities[a,b]

- Bulldozer Excavation
- Loading/Dumping
- Grading
- Transport over unpaved surfaces
- Periodic sub-surface utility work

Notes

[a] Construction pathways to be evaluated both by assuming full (required) dust control and by assuming complete lack of dust control.

[b] Construction activities will be evaluated both within the context of general, commercial construction and a specific remediation scenario.